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भाग 2 संदर्भ सौर कोशिकाओं की अपेक्षाएं

Indian Standard

SPECIFICATION FOR PHOTOVOLTAIC DEVICES

PART 2 REQUIREMENTS FOR REFERENCE SOLAR CELLS

UDC 621·383·5

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

October 1993

Price Group 3

Solar Photovoltaic Energy Systems Sectional Committee, ET 28

NATIONAL FOREWORD

This Indian Standard (Part 2) which is identical with IEC Pub 904-2 (1989) issued by the International Electrotechnical Commission was adopted by the Bureau of Indian Standards on the recommendation of the Solar Photovoltaic Energy Systems Sectional Committee, (ET 28) and approval of the Electrotechnical Division Council.

The text of IEC standard has been approved as suitable for publication as Indian Standard without deviations. Certain conventions are however not identical to those used in Indian Standards. Attention is particularly drawn to the following:

> Wherever the words 'International Standard' appear in this standard, they should be read as 'Indian Standard'.

This Indian Standard has been issued in several parts. Other parts of this Indian Standard are:

IS 12762 (Part 1) : 1989 Specification for photovoltaic devices : Part 1 Measurement of photovoltaic current voltage characteristics

IS 12762 (Part 3) Specification for photovoltaic devices : Part 3 Measurement principles for terrestrial photovoltaic PV Solar devices with reference spectral irradiance data (under preparation)

Only the English language text in the international standard has been retained while adopting it in this Indian Standard.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

SPECIFICATION FOR PHOTOVOLTAIC DEVICES

PART 2 REQUIREMENTS FOR REFERENCE SOLAR CELLS

1 Scope

This standard gives requirements for the classification, selection, packaging, marking, calibration and care of crystalline silicon reference solar cells.

2 Description

A reference solar cell is a specially calibrated cell, which is used to measure irradiance or to set simulator irradiance levels in terms of a reference solar spectral irradiance distribution.

There are two types:

- Primary: a reference cell whose calibration is based on a radiometer or standard detector conforming to the standard World Radiometric Reference (W.R.R).
- Secondary: a reference cell calibrated in natural or simulated sunlight against a primary reference cell.

3 Selection

At least two solar cells shall be selected for calibration as reference cells. The spectral response of the selected cells shall be such that errors in performance measurement of the intended test (under natural sunlight or specific simulator) due to spectral response mismatch are less than ±1%. The spectral mismatch error shall be calculated by the method described in the relevant IEC standard (under consideration).

Reference cells shall be stable devices, that is their photovoltaic characteristics shall not change by more than 5% of the initial calibration (see Clause 10).

4 Temperature measurement

Means shall be provided for measuring the reference cell junction temperature to an accuracy of ±1 °C.

5 Electrical connections

The electrical connections to the reference cell shall consist of a four-wire contact system (Kelvin probe).

6 Calibration

Each reference cell shall be calibrated in terms of its short-circuit current at (25 ± 2)°C per unit of irradiance with the reference spectral irradiance distribution $[\mathrm{AW}^{-1}\cdot\mathrm{m}^2]$.

The standard methods of calibrating both primary and secondary reference cells are described in Clauses 11 and 12. The relative spectral response and the temperature coefficient of short-circuit current of each reference cell shall be measured in accordance with the relevant IEC standards (under consideration).

7 Data sheet

Each time a reference cell is calibrated, the following information shall be recorded on a data sheet:

- Identification number
- Type (primary or secondary)
- Cell manufacturer
- Material type
- Type of package
- Calibration organization
- Site and date of calibration
- Method of calibration (refer to standard)
- Radiometer or standard lamp characteristics
- Primary reference cell identification
- Simulator characteristics
- Type of temperature sensor

  where applicable
- Relative spectral response
- Temperature coefficient of short-circuit current
- Calibration value $[\mathrm{AW}^{-1}\cdot\mathrm{m}^2]$ at S.T.C. (Standard Test Conditions)
- Claimed accuracy

8. Marking

Each reference cell shall carry a clear, indelible identification number for cross-reference to the relevant data sheet.

9 Packaging

9.1 *Measurement in natural sunlight*

The reference cells used for measurements in natural sunlight shall respond to variations in the geometrical distribution of the incident radiation in the same way as the test specimens (cells, sub-assemblies of cells, modules).

To this end, when measurements are made on multi-cells with the direct solar beam not at, or near, normal incidence to the multi-cell unit, the reference cell shall be enclosed in a multi-cell package (see Figure 1). In this case, the frame, the encapsulation system, the shape, and the size and spacing of the cells surrounding the reference cell shall be the same as in the module to be tested. The surrounding cells may be real or dummies that have the same optical properties. The dotted line in Figure 1 indicates the minimum acceptable size of the multi-cell package for outdoor testing.

9.2 *Measurement under simulators*

9.2.1 In some simulators which allow multiple reflections of light to and from the test specimen, the irradiance in the test plane may change depending on whether or not the test specimen is present.

9.2.2 Therefore, in order to measure accurately the irradiance that will be present when the test specimen is in place, the reference cells used in such simulators shall be packaged in the same way as the test specimen, so that the change in irradiance due to the multiple reflections is the same for both the reference cell and the test specimen.

Reference cells used for measurements in simulators designed to render insignificant any error from multi-reflected light may be packaged singly or, if not intended for day-to-day use, mounted in the unpackaged state on a temperature controlled block.

Alternatively, the requirements given for reference cells for use in natural sunlight may be followed.

9.3 *Single cell package*

If a single cell package is used, the following recommendations are made:

9.3.1 The field of view should be at least 160°.

9.3.2 All surfaces in the package within the cell's field of view should be non-reflective, with an absorption of at least 0.95 in the cell's wavelength response band.

9.3.3 The material used for bonding the cell to the holder should not be degraded electrically and optically. Its physical characteristics should remain stable over the entire period of intended use.

9.3.4 The use of a protective window is recommended. If the cell is to be calibrated or used in total sunlight, the space between the window and the cell should be filled with a stable, transparent encapsulant. The refractive index of the encapsulant shall be similar (within 10%) to that of the window to minimize errors due to the internal reflection of light at high angles of incidence. The transparency, continuity and adhesion of the encapsulant should not be adversely affected by ultra-violet light and operational temperatures.

Figure 2 shows an example of a suitable single cell package.

10 Care of reference cells

The window of a packaged reference cell shall be kept clean and scratch free.

Unpackaged reference cells shall be preserved against damage, contamination and degradation.

The calibration of reference cells in frequent use shall be cross-checked at intervals of no more than one month by comparing their short-circuit currents under the same irradiance. If there is any change in the current ratios beyond ±1%, the cells shall be re-calibrated.

All reference cells shall be recalibrated at least every 12 months.

11 Calibration of primary reference cells

The calibration method and its execution shall be to a high level of accuracy within ±n% (±n% to be determined).

Note.- The word "accuracy" (used in accordance with ISO standards) is dependent upon the method used for calibration. However, repeatability within ±1% can be achieved.

12 Calibration of secondary reference cells

Secondary reference cells shall be calibrated in natural or simulated sunlight against a primary reference cell. The spectral response match between the primary and secondary reference cells shall be such that the spectral mismatch error under the illumination used for calibration is less than ±1% as determined by the procedure given in the relevant IEC standard (under consideration).

12.1 *Natural sunlight*

Calibration in natural sunlight shall be carried out under the following conditions:

12.1.1 Clear, sunny weather, with the diffuse irradiance not greater than 25% of the global irradiance.

12.1.2 No observable cloud formations within a 30° half-angle cone surrounding the sun.

12.1.3 Total irradiance (sun + sky + ground reflection) not less than 800 W·m^{-2}, as measured by the primary reference cell.

12.1.4 Air mass between AM1 and AM2.

12.1.5 Radiation sufficiently stable so that the variation in reference cell short-circuit current is less than ±0.5% over the time taken for a measurement.

12.2 *Simulator*

If simulated sunlight is used, the simulator shall be of Class A in accordance with the relevant IEC standard (under consideration).

12.3 *Calibration procedure*

12.3.1 Before the calibration, measure the relative spectral response and temperature coefficient of short-circuit current of the secondary reference cell, using the procedures specified in the relevant IEC standards (under consideration).

12.3.2 Mount the primary and the secondary reference cells coplanar and in close proximity on the same mount. Connect to the current and temperature measuring instruments. If possible, control the cell temperature at (25 ± 2)°C. If it is not practicable to control the temperature of the cells, shade them from the light except when making current measurements. (Shading is not necessary with pulse simulators.)

12.3.3 Adjust the mount so that the solar beam or centre-line of the simulator beam is normal to the cell surfaces within ±5°.

12.3.4 Record simultaneous readings of the short-circuit currents and temperatures of both reference cells.

12.3.5 Repeat step 12.3.4 until five successive sets of readings are obtained in which the ratio of the short-circuit currents, corrected to 25 °C, does not vary by more than ±1%.

12.3.6 When calibrating in natural sunlight, repeat the steps 12.3.2 to 12.3.5, inclusive, a minimum of five times on at least three separate days.

12.3.7 From the acceptable data, calculate the mean ratio:

$$\frac{\text{Short-circuit current of secondary reference cell at 25 °C}}{\text{Short-circuit current of primary reference cell at 25 °C}}$$

12.3.8 Multiply the calibration value of the primary reference cell by the calculated mean ratio to obtain the calibration value of the secondary reference cell.

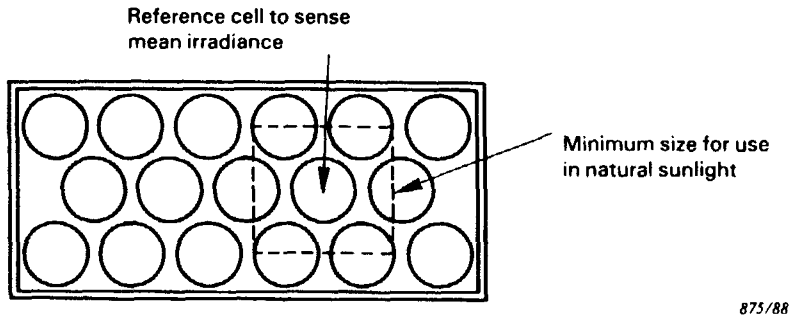
Reference cell to sense mean irradiance
Minimum size for use in natural sunlight
875/88

Figure 1 - Reference cell in a multi-cell package.

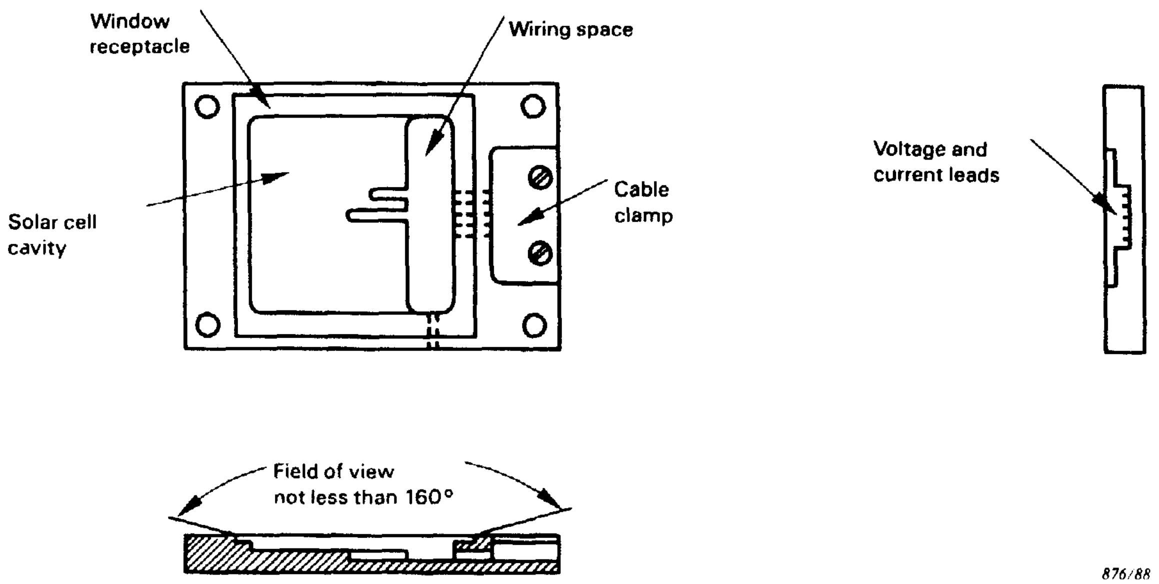

Figure 2 - Single-cell package

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Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition by referring to the latest issue of 'BIS Handbook' and 'Standards Monthly Additions'. Comments on this Indian Standard may be sent to BIS giving the following reference:

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BUREAU OF INDIAN STANDARDS

Headquarters:

Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110002
Telephones : 331 01 31, 331 13 75
Telegrams : Manaksanstha
(Common to all Offices)

Regional Offices :		Telephone
Central :	Manak Bhavan, 9 Bahadur Shah Zafar Marg NEW DELHI 110002	331 01 31 331 13 75
Eastern :	1/14 C. I. T. Scheme VII M, V. I. P. Road, Maniktola CALCUTTA 700054	37 84 99, 37 85 61 37 86 26, 37 86 62
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Southern :	C. I. T. Campus, IV Cross Road, MADRAS 600113	235 02 16, 235 04 42 235 15 19, 235 23 15
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